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Effect of antitranspirants application on yield and yield components in soybean (*Glycine max L.*) under limited irrigation

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Abstract

In order to evaluate the effect of some antitranspirants on plant traits, yield and yield components in soybean (*Glycine max L.*) under limited irrigation an experiment was conducted in the research field of Urmia university in 2010. The experiment was arranged in a complete randomized block design with four replications. Antitranspirants consisted of Kaolin (6%), Chitosan (0.1%), castorbean oil (1%), magnetic water and control (without antitranspirant). These materials applied 60 days after planting (flowering stage) and in seed formation stage. After spraying the plants with antitranspirants, irrigation in these stages were interrupted in all plots and irrigation intervals increased from 10 days to 20. The results showed that the application of antitranspirants significantly increased stem height, node number, stem diameter, number of pods and number of seeds per plant, thousand seed weight, seed yield, biological yield and harvest index in treated plants but the number of seeds per pod was not affected by these antitranspirants. Among the materials used kaolin had the most influence on seed yield thus seed yield increased %23/85 compared to control . Findig this experiment suggest that using antitranspirants can be effective by reducing the effect of water stress in soybean product.

Key words: Castor bean oil, Chitosan, Kaolin, Magnetic water, Soybean

INTRODUCTION

Soybean (*Glycin max L.*) is an annual plant, in the family of Fabaceae with the direct and relatively full leaf grows. This plant is one of the most important oil and protein plants. Soybean oil makes up 20 to 25 percent fat, 30-35 percent of oil production in world [1]. Field irrigation maintain soil moisture environment in a good condition and minimize water stress of the crop during the growing season [2],[3] and[4] therefore in the arid areas, water use efficiency for irrigation should be seriously considered. Lack of moisture is one factor that limits the growth of soybean So that if the availability of water for roots not to be enogh or transpiration rate to be high the plant will experience drought [5]. Water limits, caused the possibility of prolonged periods of irrigation or postponement of two or three irrigation during critical growth stages of soybean, such as formation of the flowers, pods, seeds per pod growth (filling) and a general decrease of growth, shoot
length, dry weight, decreased protein, proline accumulation and degradation of the enzyme [6].

Plant through various mechanisms such as stomatal closure, reduced transpiration, root weight and length, keeping up photosynthesis, respiration and osmoregulation can increase the resistance to drought [6]. In study of Robins and Domingo, 1956 [7], stress occurred 15 days before flowering by reducing the number of pods per plant and within 22 days after flowering by reducing the number of pods and seeds per pod influenced on yield. Roughly one percent of total water consumption of plant roots is used for growth, the rest (99-98%) is lost water vapor from the plant into the atmosphere if a practical way can be found to reduce this value, requiring to water especially in arid regions will be largely reduced as a result of increasing water use efficiency by reducing the frequency of irrigation through the slow rate of soil water depletion with using antitranspirants [8].

Antitranspirants were grouped into three categories, namely film-forming types (which coat leaf surface with films that are impervious to water vapor), reflecting materials (which reflect back a portion of the incident radiation falling on the upper surface of the leaves) and stomatal closing types (which affect the metabolic processes in leaf tissues [9]. Kaolin (surround WP) is a non-abrasive, non-toxic aluminosilicate ($Al_4Si_4O_{10}$ $(OH)_8$) clay mineral that has been formulated (Engelhard Corporation, Iselin, NJ) as a wettable powder for application with conventional spray equipment [10]. A reflective Kaolin spray was found to decrease leaf temperature by increasing leaf reflectance and to reduce transpiration rate more than photosynthesis in many plant species grown at high solar radiation levels [11]. Reflecing antitranspitants were found that to be non-toxic and have an effectiveness in longer period than metabolic types [12].

Cantore, et al, 2009 [10], investigated the underlying mechanism asserted by kaolin on tomato physiology by evaluating its effect on leaf, canopy and inner fruit temperatures, gas exchange at the leaf and canopy scales, above ground biomass, yield and fruit quality. In treated

plants, stomatal conductance decreased by 53%, resulting in reductions of 34 and 15% in transpiration and internal CO2 concentration, respectively. Marketable yield in kaolin-treated plants was 21% higher than those measured in control plants; this is possibly related to the reduction in sunburned fruit and those damaged by insects, respectively, and to the 9% increase in mean fruit weight, Kaolin treatment increased lycopene fruit content by 16%. Moftah and Al-Humaid, 2005 [13], in study of the effect of kaolin and Vaporgard on the photosynthesis and water relations of potato plants concluded that by the use of both antitranspirants efficiency and photosynthetic activities increased in plants under drought stress .Their results showed that water use efficiency (WUE) in plants treated with kaolin were significantly higher than plants treated with Vaporgard. Chitosan is a natural, biodegradable polysaccharide polymer which serves as major structural component of the exoskeleton of crustaceans and insects [14]. Chitosan is commercially derived from shells of crabs, shrimp, and lobsters.

Bittelli et al, 2001 [15], were found that foliar application of chitosan reduced water use of pepper plants by 26–43% while maintaining biomass production and yield. Castorbean oil as a film forming material and magnetic water were used in this study. One of the changes in magnetic water is the arrangement of electrical charges causes water molecules change to magnetic water. In the water, over 70% of the water molecules form irregular and they have positive and negative charges in their natural position if the water molecules (cations and anions) change from disorder to order the charge of water molecules in these circumstances will be different than regular water and the formation of smaller molecules of water, increase the number of water molecules per unit volume also increase the water solubility. Assuming the formation of smaller water molecules in the magnetic water and absorption through the stomata and reduce transpiration we used magnetic water in this study .The purpose of this study, was investigate of some antitranspirats effect on the vegetative and reproductive characteristics of soybean under limited irrigation.

MATERIALS AND METHODS

The experiment was conducted in the research field of agricultural faculty, Urmia University, Iran during the 2010 growing season in field conditions. Some physical and chemical properties of the soil are given in (Table 1). The experiment was arranged in a Complete Randomized Block Design with four replications. The deep plowing was in the fall and surface plowing and leveling with a ammonium nitrate and ammonium phosphat fertilizer according to soil test was done in spring. Plots were performed 3×4 meters in size and each plot with its surrounding plots was half meter away. Distances between blocks was 1 meter and distance between planting rows was 60 cm. Before planting, seeds were inoculated with soybean nitrogen fixing bacteria (*Japonicum Bradyrhizobium*). Planting was done in June. The seeds were planted at 10 cm intervals with 3-5 cm soil depth. To ensure achieving the desired density, 3-4 seeds were planted in each pile and in the time of thinning at the V2 stage (the leaves ternate) to adjust the distance between the plants, additional plants on rows were removed. During the growing season, weeding was done by hand when it was necessary. In this study was used from cv. Williams of soybean. Antitranspirants applied with the following composition:

i) Kaolin, at 6% (w/v) [16]. ii) Chitosan (CHT Fluka), 76 kDa molecular weight (MW) and 85% deacetylation degree (DD), at a concentration of 1 g L^{-1} was dissolved in 0.01M acetic acid (AA, pH 5.6, adjusted with NaOH) [15],[17]. iii) Coatorbean oil at 1% was prepared [18]. iiii) Magnetic Water and iiiii) control treatment (without the antitranspirants). The solutions were sprayed 60 days after planting (early flowering) and in seed formation stage on surfaces of the leaves by a hand-held sprayer [19],[20]. Before spraying antitranspirants materials, irrigation was done every 10 days after using antitranspirants, irrigation in these stages was interrupted in all plots and irrigation intervals increased from 10 days to 20. Traits studied were: plant height, node number, stem diameter, number of pods per plant, seeds per pod, the number of seeds per plant, thousand seed weight, grain yield, biological yield and harvest index. In early October, the crop was harvested. In every plot, two rows of outside and half meters from the beginning and end of rows was removed to reduce the marginal effects and the rest was harvested for grain yield and finally grain yield were calculated with a constant humidity of 13% in weight. To determine the biological yield of plants seeds plants were maintained for 48 hours in the oven with a temperature of 75 degrees and harvest index was obtained of grain yield divided to biomass (total weight of plant seeds and other organs).

It should be noted that before harvesting and after removal of the marginal effects, 10 plants selected from each plot randomly to determine the yield components and morphological traits. In the laboratory, the number of pods per plant and also after separate the seeds from the shell, the number of seeds per plant was determined then from dividing the number of seed per plant on the number of pods per plant was determined the number of seeds per pod.

EXPERIMENTAL RESULTS

Analysis of variance indicated positive effects of using antitranspirant on vegetative and reproductive characteristics of soybean under limited irrigation. It sould be noted that due to the non-toxic effects of these substances can be considered in organic farming.

Antitranspirants effect on vegetative characters

According to the results of this study plant height, increased by antitranspirants to compare with control but it was not significant by magnetic water and castorbean oil (Table 2). All antitranspirants treatments significantly increased the number of nodes compared with control .the materials used caused an increasing in stem diameter. Exept Magnetic Water and chitosan treatments other treatments showed significant difference with control (Table 2). Among the antitranspirant materials used kaolin showed the better results than other antitranspirants in increasing studied vegetative traits compared with control.

Antitranspirants effect on the number of pods and seeds per plant - the number of seeds per pod

The results showed that among yield components, the number of pods and seeds per plant, increasd in affected with antitranspirants and except magnetic water all of the antitranspirant treated showed a significant difference compared with control (Table 2). The number of seeds per

pod was not affected by antitranspirants and showed no significant difference with control.

Antitranspirants effect on thousand seed weight - Total seed yield

Exept Manetic Water all antitranspirants materials used significantly increased thousand seed weight compared with control (Fig 1) Increasing in the number of pods and seeds per plant also seed weight significantly increased the seed yield as results of using antitranspirants (Kaolin, Chitosan and Castorbean oil) compared to control (Table 2,Fig1,2) . Among the materials used kaolin had the most influence on seed yield so much by foliar application of kaolin, seed yield was increased %23/85 compared to control (without antitranspirant).

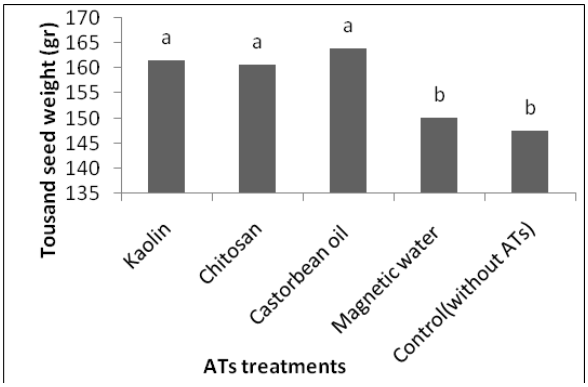

Figure 1. The effect of antitranspirants used (Kaolin, Chitosan, Casrorbeanoil, Magnetic water and control) on thousand seed weight in soybean under limited irrigation. Different letters over the columns, when present,indicate statistical differences at ≤p0.05 according to Duncan Multiple Range Test (DMRT).

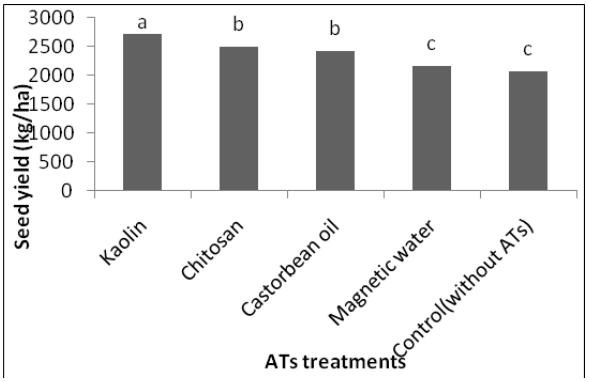

Figure 2. The effect of antitranspirants used (Kaolin, Chitosan,Casrorbeanoil, Magnetic water and control) on seed yield in soybean under limited rrigation Different letters over the columns,when present,indicate statistical differences at p≤0.05 according to Duncan Multiple Range Test (DMRT).

Antitranspirants effect on Biological yield and harvest index

Biological yield and harvest index were also affected by antitranspirants. As the use of these materials increased biological yield. The highest biological yield was in using kaolin (5680.25Kg/ha) and lowest in control (without antitranspirant application) (4964.37Kg/ha). there was not a statistically significant differences between the antitranspirants. The magnetic water treatment showed no significant difference with control treatment. Harvest index comparison showed that the application of antitranspirant materials under the limited irrigation increased harvest index in soybean plant as compared to control .The highest harvest index (44.24%) was in using of the kaolin and the lowest (41.77%) in the control. Magnetic water treatment showed no significant difference with control also there was no significant difference between chitosan and castorbean oil (Fig 3, 4).

Table 1. Physical and chemical characteristics of soil samples.

Soli depth (cm)	Texture	EC	pH	Clay%	Silt%	Sand%	N%	P P_{ppm}	K P_{ppm}
0-30	Loam	1.1	8.2	26	35	39	6	0.4	250

Table 2. Effects of Kaolin, chitosan, castorbean oil and magmetic water sprays on the plant hight, node number, stem diameter, seed number in plant, seed number in pod in soybean plants under limited irrigation condition

Treatments	plant height	node number	stem diamete (cm)	pod number/ plant	seed number/ plant	seed number/ pod
kaolin	107.1a	17.43a	2.05ab	48.95a	138.3a	2.81a
Chitosan	97.02 b	17.07b	1.94bd	44.4b	123.4b	2.80a
Castorbean oil	95.29bc	17.00 b	2.13a	41.45c	116.2c	2.78a
magnetic water	94.18bc	16.53c	1.90cd	35.65d	98.78d	2.78a
control	90.43c	15.76d	1.80d	31.71d	93.94d	2.79a

Means in the same column followed by the same letter are not significantly different at the 1% level according to Duncan's test.

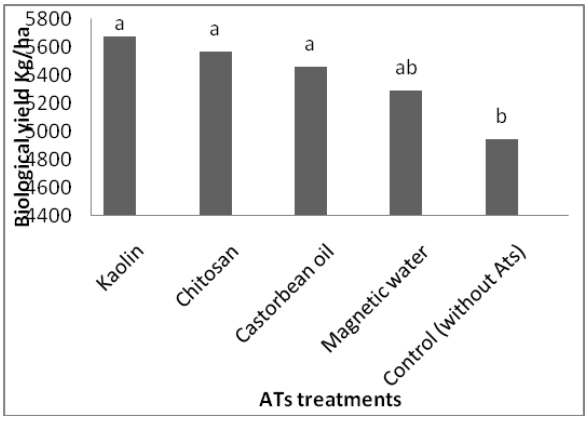

Figure 3. The effect of antitranspirants used (Kaolin, Chitosan, Casrorbeanoil, Magnetic water and control) on Biological yield in soybean under limited irrigation. Different letters over the columns, when present,indicate statistical differences at p≤0.05 according to Duncan Multiple Range Test (DMRT).

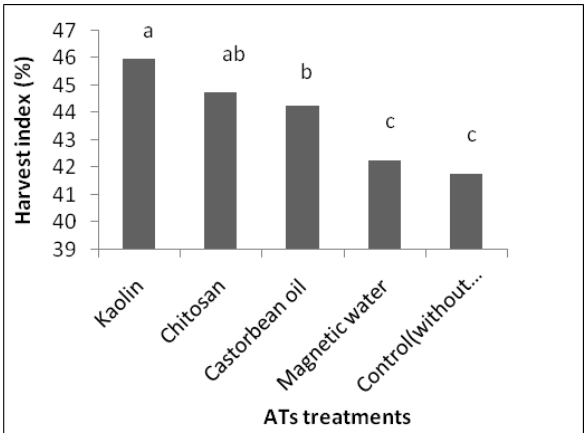

Figure 4. The effect of antitranspirants used (Kaolin, Chitosan, Casrorbeanoil, Magnetic water and control) on Harvest index in soybean under limited irrigation. Different letters over the columns, when present,indicate statistical differences at p≤0.05 according to Duncan Multiple Range Test (DMRT).

DISCUSSION

Antitranspirants effect on vegetative characters

Water shortage, reduced stem height, node number, stem diameter in the control treatment (without spraying with antitranspirants) The reason of this case, is the negative effect of water stress on photosynthetic processes, nutrition, hormones and plant water relations thus the using of antitranspirants by increasing plant water potential, photosynthesis and degradation processes that are essential for transport and metabolism of plant cell size [21], [22] has caused an increase in vegetative traits compared to controls.

Researcher reported that as a result of foliar applications of kaolin, the growth parameters increased due to reduction in water loss through transpiration, increasing in reflection of solar radiation, leaf area and soil moisture conditions [23].Similarly foliar applications of kaolin increased parameters of the growth [24] this result supports the present findings. Using atrazine, paraffin, wax and citowett as antitranspirants agents increased some vegetative characteristics in corn under limited irrigation when compared with control [19].

Antitranspirants effect on the number of pods and seeds per plant - the number of seeds per pod

Reduce the number of pods per plant in control plants, was in resulting of fewer flowers and pods, and severe loss of water due to lack of irrigation at flowering stage. Korte et al, 1983 [2], concluded that lack of access to water is the most important factor in the loss of flowers and pods because sufficient moisture prevent from degenerative changes in the region of flower formation. The results in this study obtained that use of antitranspirants with increasing potential of water thereby reducing transpiration rate prevented from degenerative changes in the region of flower fomation compared with control.

Antitranspirants effect on thousand seed weight - Total seed yield

Since the thousand seed weight was determined in the late reproductive period, Shortage of irrigation water applied at flowering and seed formation stages also reduced the thousand seed weight of plants. Increaseing the yield of wheat, corn, sorghum and soybean by the use of antitranspirants (the film forming and substances that are causing the closing of stomata) were reported [19],[25],[18] and [26]. Some researchers also reported that the using antitranspirants may reduce water loss through transpiration; consquently the amount of used water and increased yield of cotton plants by 63 % [27],[28] and [29]. Bittelli et al, 2001 [15], showed that weekly Chitosan treatments during the whole growing season did not reduce biomass and yield significantly in pepper plants.

Antitranspirants effect on Biological yield and harvest index

Plants treated with kaolin produced more Biological yield than the other treated plants. Increased Biological yield production by antitranspirants application might also be attributed to the increasing water potential in plant which developed during the period of measurement. Increase in dry matter of Rapeseed by using antitranspirants under low soil moisture due to increasing water potential of plants treated thus increasing the relative humidity content of leaves was reported [30] which is consistent with results obtained in this study. Yadav & Kumar, 1998 [20], reported that foliar application of atrazin (as an antitranspirant) on corn plants increased biological yield in treated plants than untreated also increasing the percentage of dry matter of banana with foliar application of antitranspirants (MgCo3, linseed oil and kaolin) reported by researchers [24]. Pandey et al, 1984 [3], reported that with reduced in water consumption, harvest index also declined as a result of the greater impact of water deficit on reproductive processes than vegetative.

Probably as a result of using antitranspirants improved metabolic activity, enzymes, protein synthesis so increased harvest index. The successful use of an antitranspirant is when the relative stomata closure rather than reduced photosynthesis, transpiration will be severely reduced. An antitranspirant that cause partial stomatal closure can increase the total resistance to the movement of water vapor over the entire resistance against the movement of Co2 thus can expect that an antitranspirant, decrease the transpiration rate more than net photosynthesis rate [31]. It can be stated that the antitranspirants materials used in this research under limited irrigation could influence on vegetative and reproductive characteristics so compensate partly of soybean yield loss due to for water shortages while the control plants (without antitranspirants) due to

lack of water had lower performance than treated plants. Treated plants with kaolin in the most studied traits had better results than other antitranspirants materials. Castorbean oil also achieved the highest thousand seed weight comperd with other treatments. Magnetic water showed no significant differences in most traits.

Reducing of transpiration through the leaves of plants treated with antitranspirants, increased plant water potential and water use efficiency therefore with interrupting irrigation, plants treated were not encountered with water shortage so in dry and semi dry areas that face with water shortage antitranspirants might be as appropriate tool to conserve water use in agriculture.

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